New York Climate & Health Project

Independent and Joint Impacts of Heat and Ozone on Mortality Risk Under a Changing Climate

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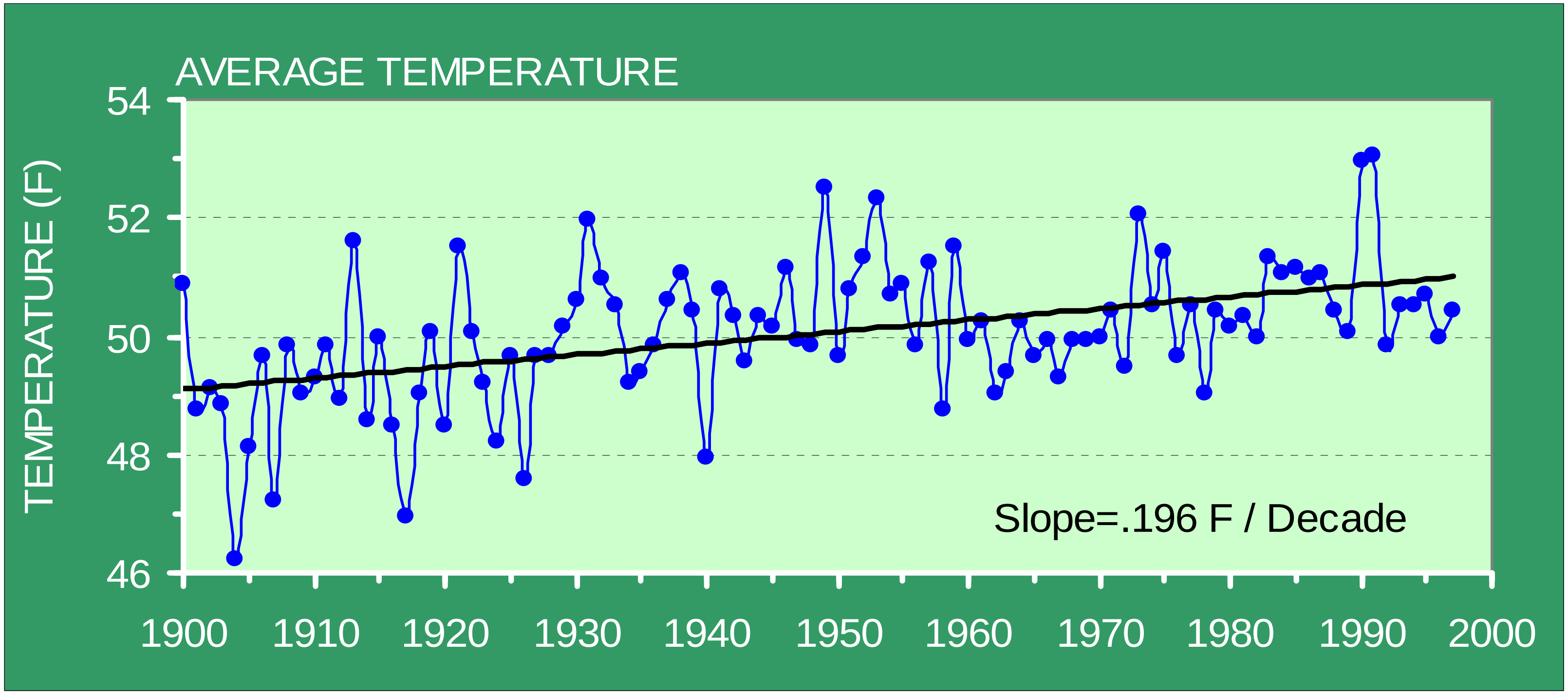
New York Climate & Health Project

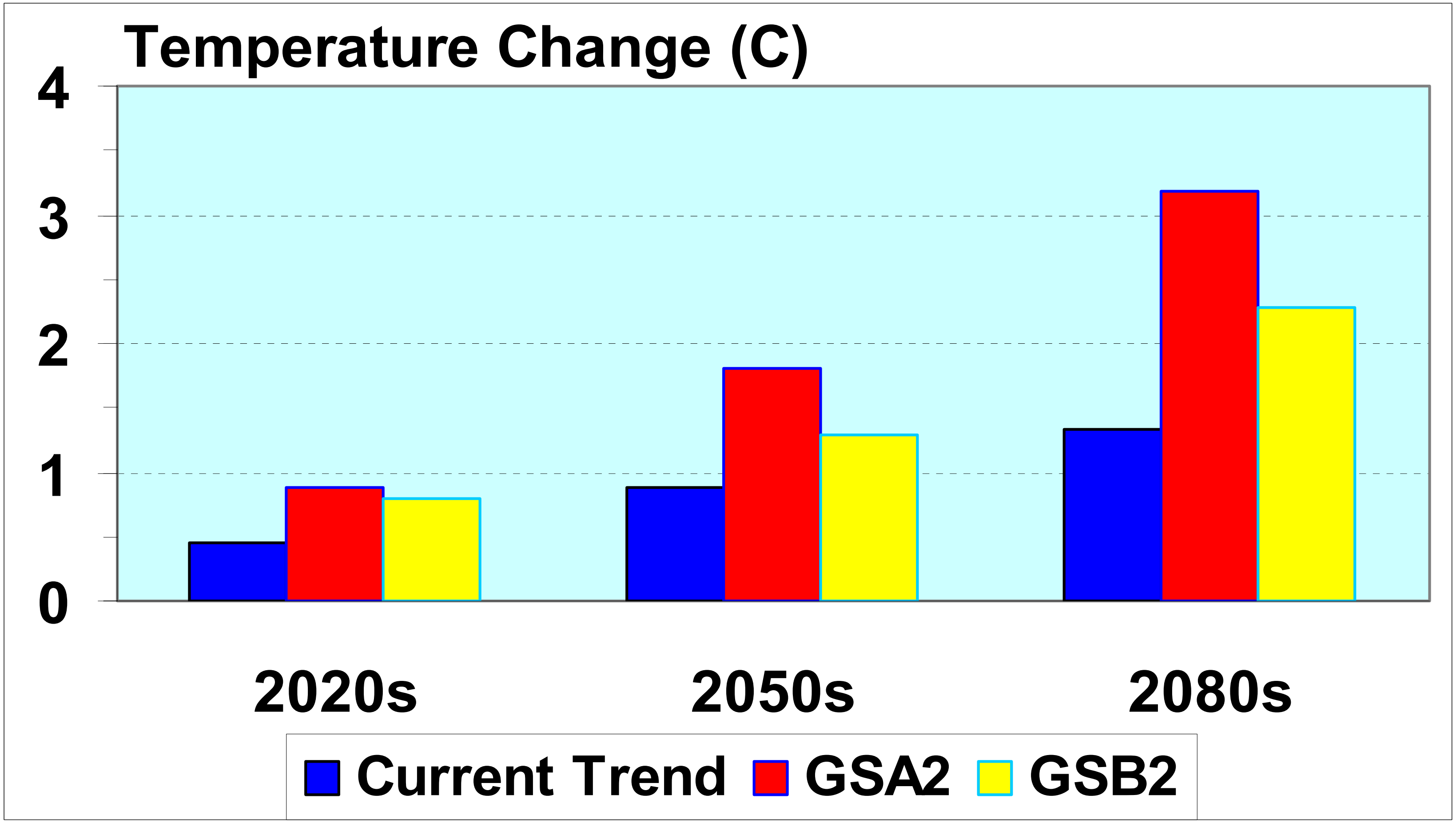
Can we assess potential future health impacts of heat and air quality at regional to local scales resulting from global climate change?

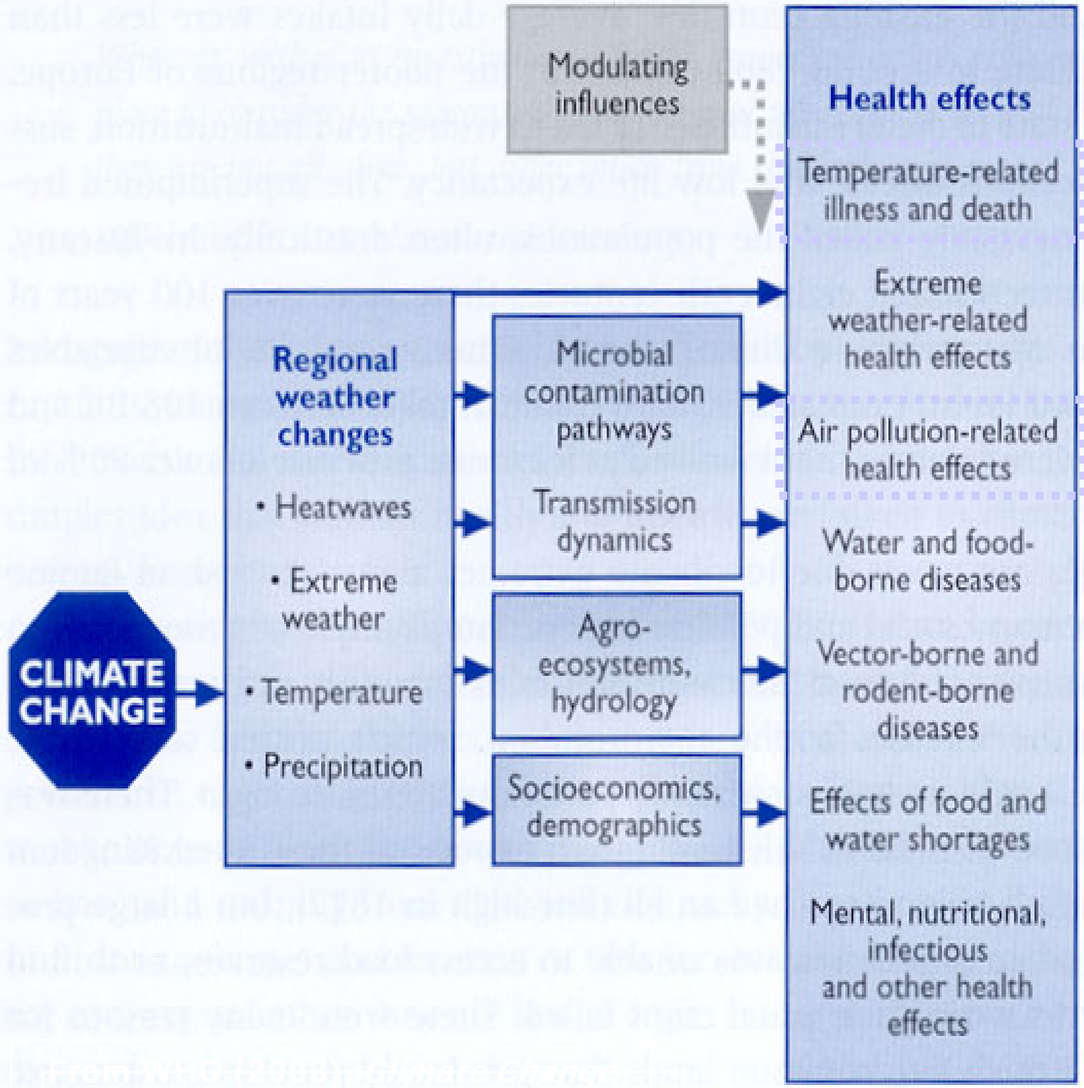
NY Regional Temperature Trends



Note: 23-station average for 31-county region,corrected for urban heat island effect.
Graph from NASA-GISS, MEC/NYCHP Team

Climate models predict further warming





From WHO (2003), *Climate Change and Human Health*

Climate Change and Public Health

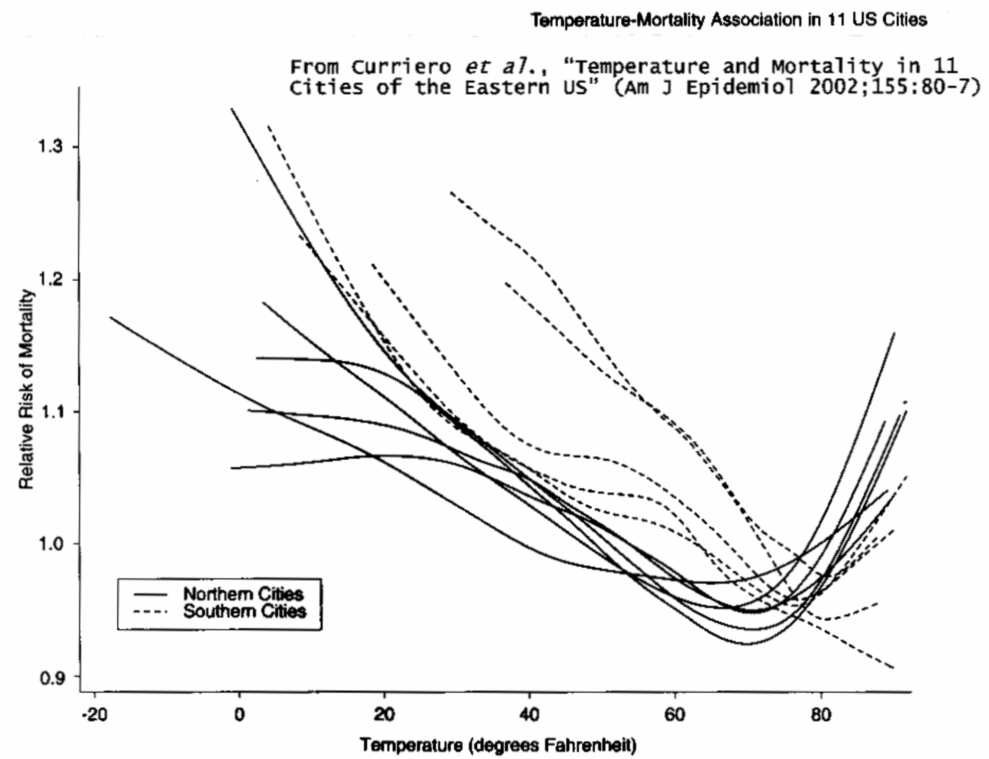
Heat & Acute Deaths

Extreme heat events have been linked extensively to immediate increases in death counts

Though uncertainties remain, same-day mean temperature is a useful predictor of mortality risk

Shape of temperature-mortality transfer function differs by location and possibly over time

Estimation of transfer function in time series models hasn't usually taken account of air pollution effects

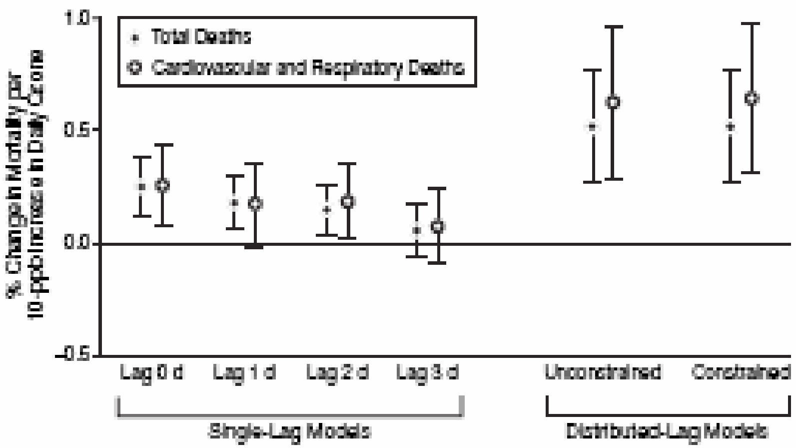


IGURE 1. Temperature-mortality relative risk functions for 11 US cities, 1973–1994. Northern cities: Boston, Massachusetts; Chicago, Illinois; ew York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, DC. Southern cities: Charlotte, North Carolina; Atlanta, eorgia; Jacksonville, Florida; Tampa, Florida; and Miami, Florida. °C = 5/9 × (°F − 32).

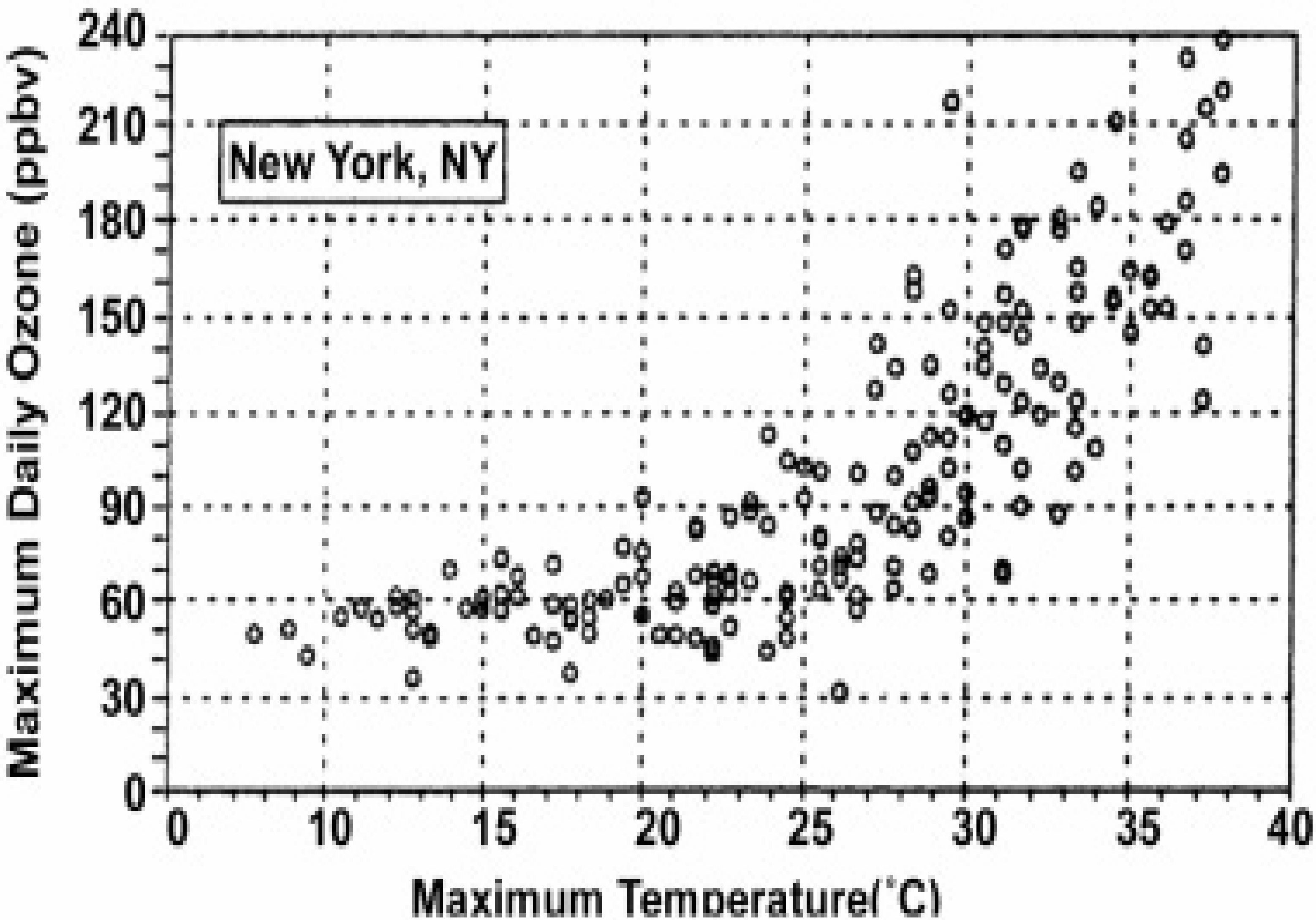
Tropospheric Ozone & Acute Deaths

- **Mortality effects of ozone have been demonstrated in time series studies, controlling for temperature and other pollutants**
  - **E.g., Kinney and Ozkaynak, Environ Res 1991; Bell et al., JAMA 2004**
- **Ozone formation is sensitive to temperature**
- **Effects of climate change on ozone and associated mortality risk have not been examined extensively**

Figure 1. Percentage Change in Daily Mortality for a 10-ppb Increase in Ozone for Total and Cardiovascular Mortality, for Single-Lag and Distributed-Lag Models

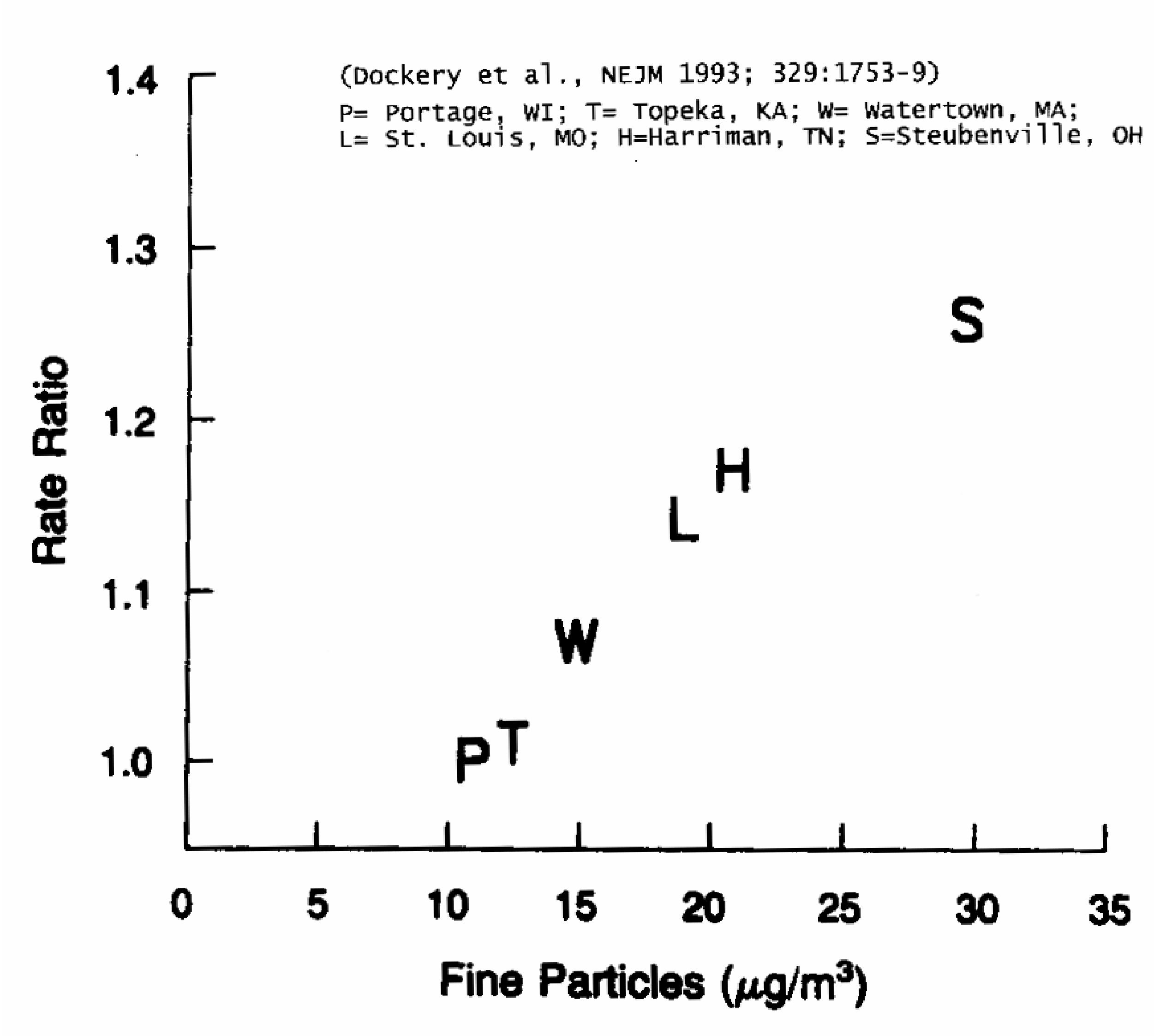


The single-lag model reflects the percentage increase in mortality for a 10-ppb increase in ozone on a single day. The distributed-lag model reflects the percentage change in mortality for a 10-ppb increase in ozone during the previous week. Error bars indicate 95% posterior intervals.



Source: US EPA (1991); in Kleinman and Lipfert, 1996.
Note threshold~90°F (32°C)

Don’t Forget Particles



Motivation

High temperatures and air pollution are current mortality risk factors in urban areas like New York City

Both of these environmental factors are sensitive to climate change

It is of interest to develop an integrated modeling system for assessing potential future health impacts of heat and air pollution under various scenarios of climate change.

The New York Climate and Health Project was designed to address this need

Approach

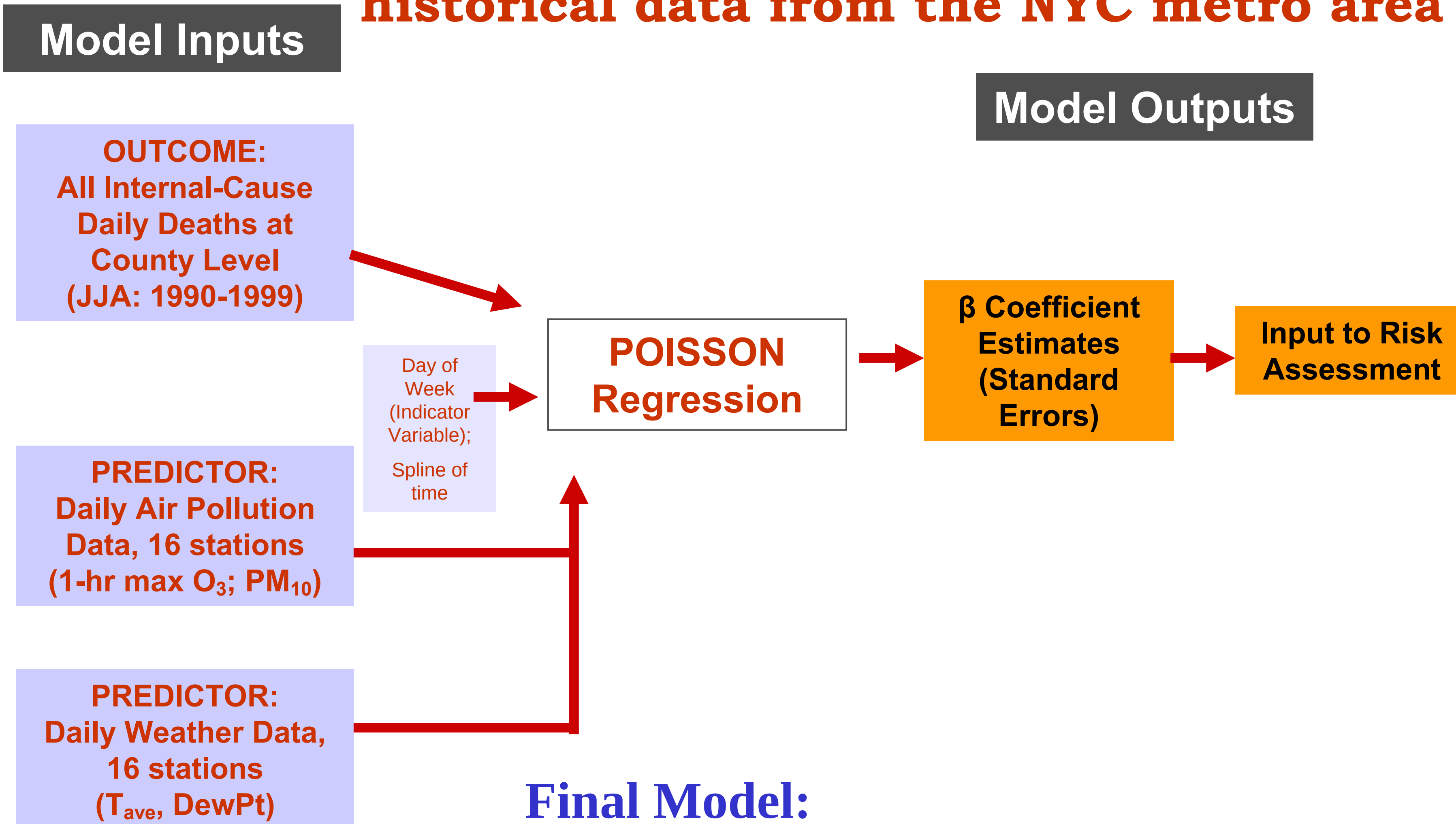
Develop exposure-response functions for temperature, ozone, and PM_{10} using historical data from the NYC metro area

Develop an integrated modeling system that includes modules for global climate, regional climate, and regional air quality

Examine alternative greenhouse gas growth scenarios

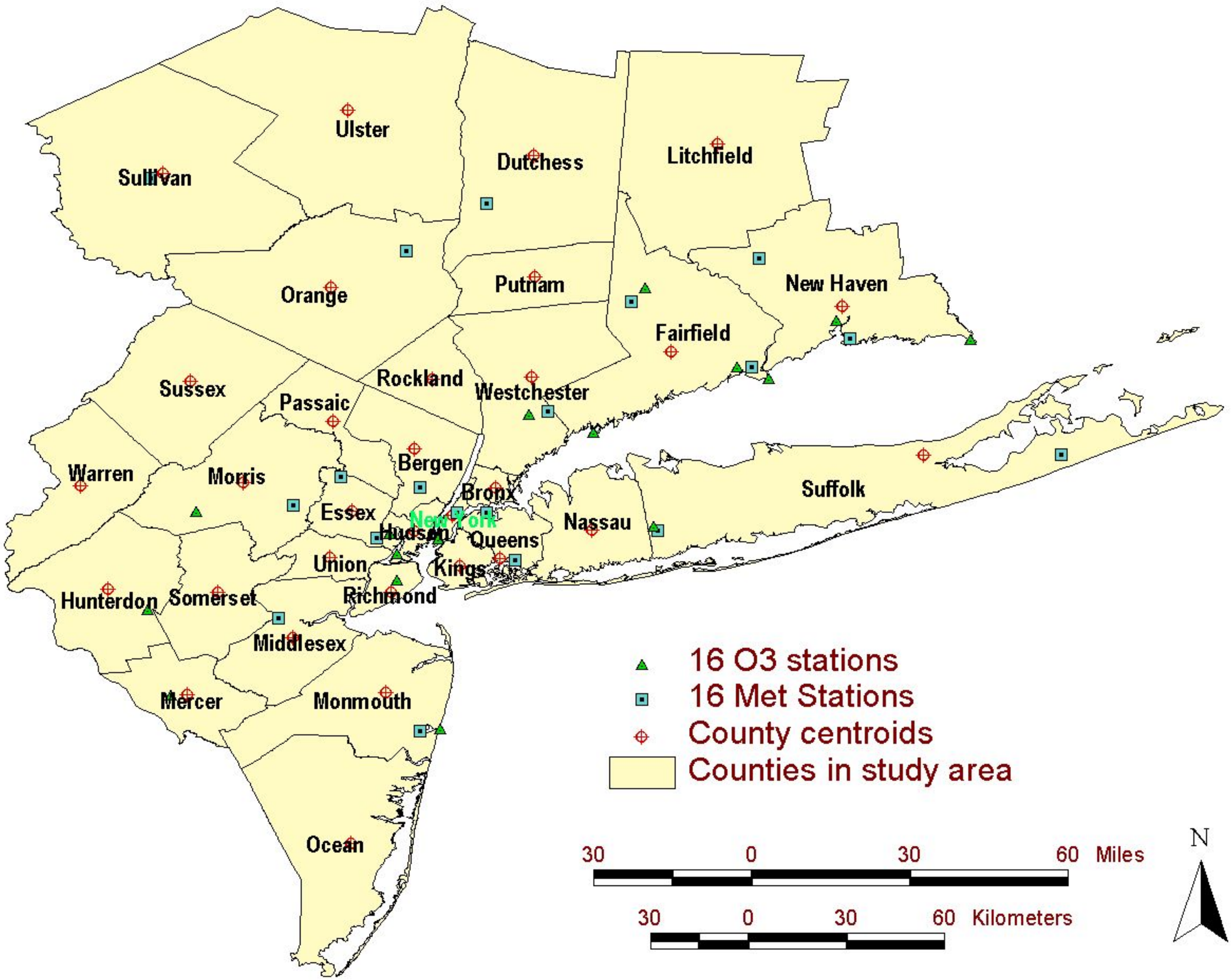
Combine to assess potential mortality risks in the NYC metro area in the 21st century

1. Develop exposure-response functions for temperature, ozone, and PM_{10} using historical data from the NYC metro area



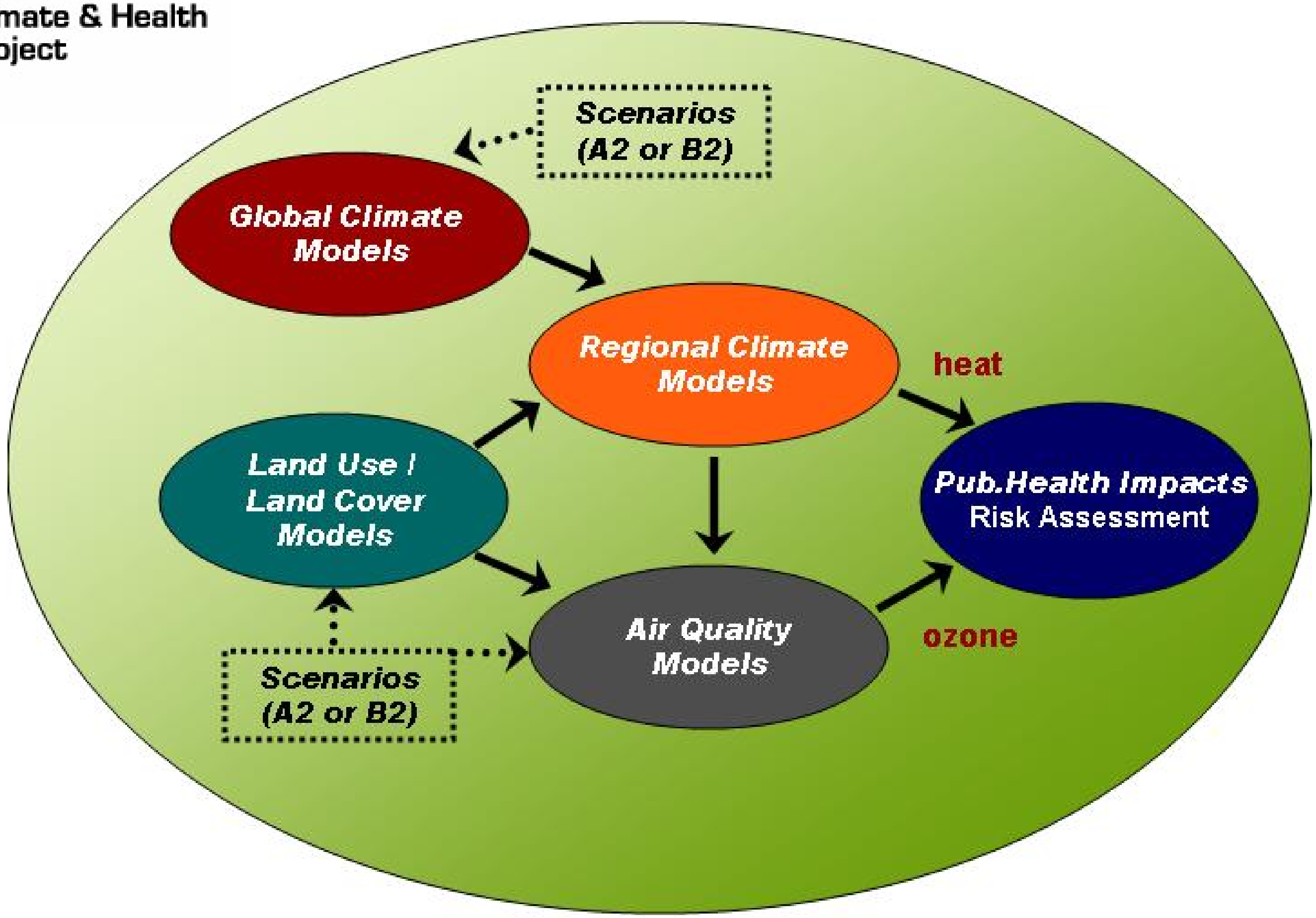
Final Model:

$$\log(\text{daily deaths}) = \text{DOW} + \textit{spline}(\textit{time}) + \beta_1(\text{mean } T_{lag0})^{1\text{-}3} + \beta_2(\textit{max } O_{3\ lag0\text{-}1})$$


Ulster
Sullivan
Dutchess
Litchfield
Orange
Putnam
New Haven
Fairfield
Rockland
Sussex
Passaic
Westchester
Bergen
Warren
Morris
Bronx
Essex
New York
Nassau
Suffolk
Hudson
Queens
Union
Kings
Hunterdon
Somerset
Richmond
Middlesex
Mercer
Monmouth
Ocean
16 O3 stations
16 Met Stations
County centroids
Counties in study area
30 0 30 60 Miles
30 0 30 60 Kilometers
N

2. Develop an integrated modeling system that includes modules for global climate, regional climate, and regional air quality

New York
Climate & Health
Project

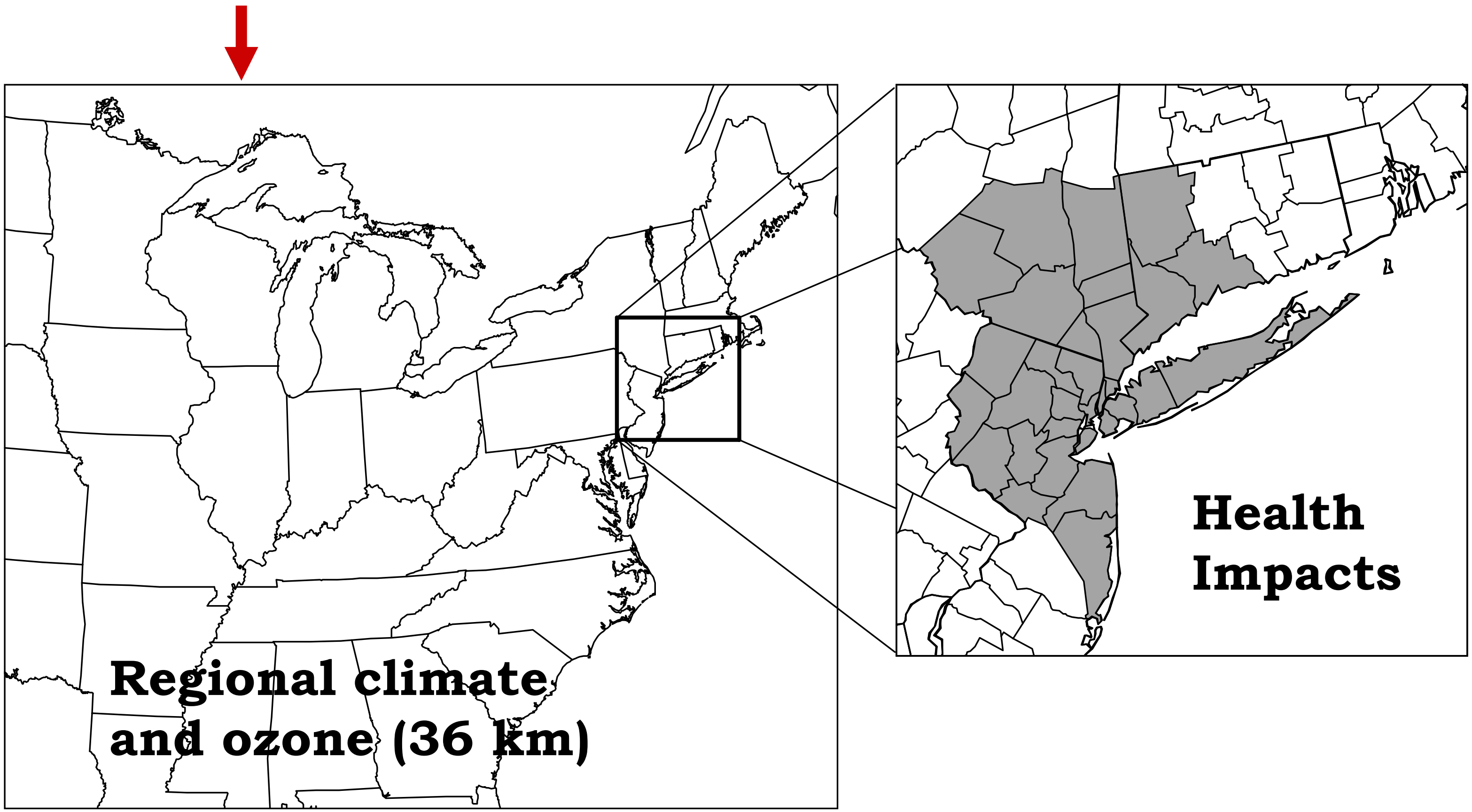


Methods 1:
Model Setup

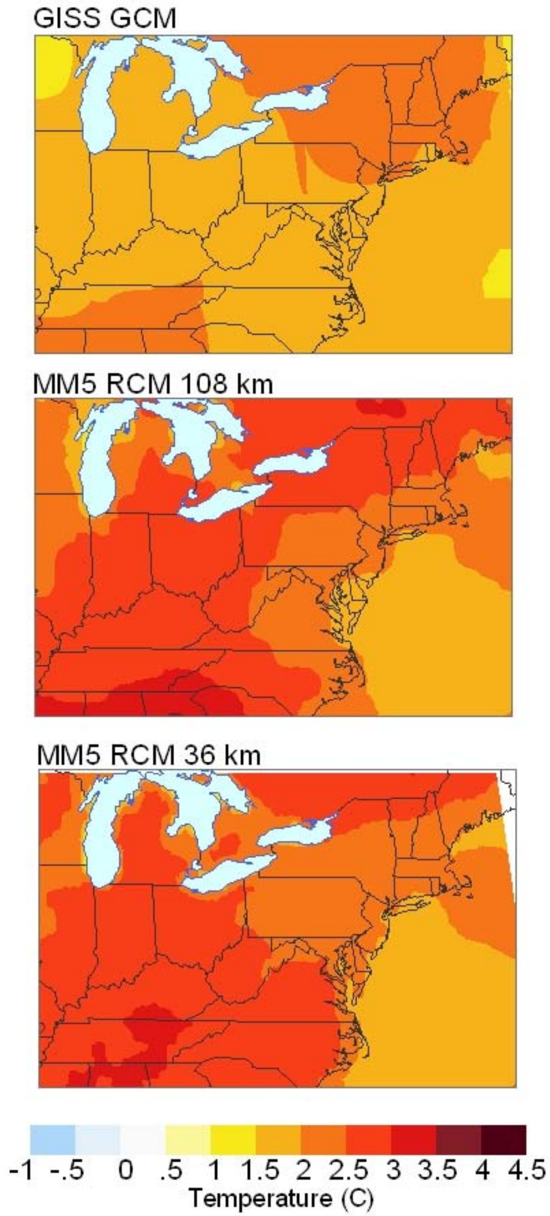
- GISS coupled global ocean/atmosphere model driven by IPCC greenhouse gas scenarios ("A2" and "B2")
- MM5 regional climate model takes initial and boundary conditions from GISS GCM
- MM5 is run on 2 nested domains of 108km and 36km over the U.S.
- CMAQ is run at 36km to simulate ozone
- 1996 U.S. Emissions processed by SMOKE and – for some simulations - scaled by IPCC scenarios
- Simulations periods : June – August 1993-1997
  June – August 2023-2027
  June – August 2053-2057
  June – August 2083-2087

Modeling domains

Global climate (4x5°)

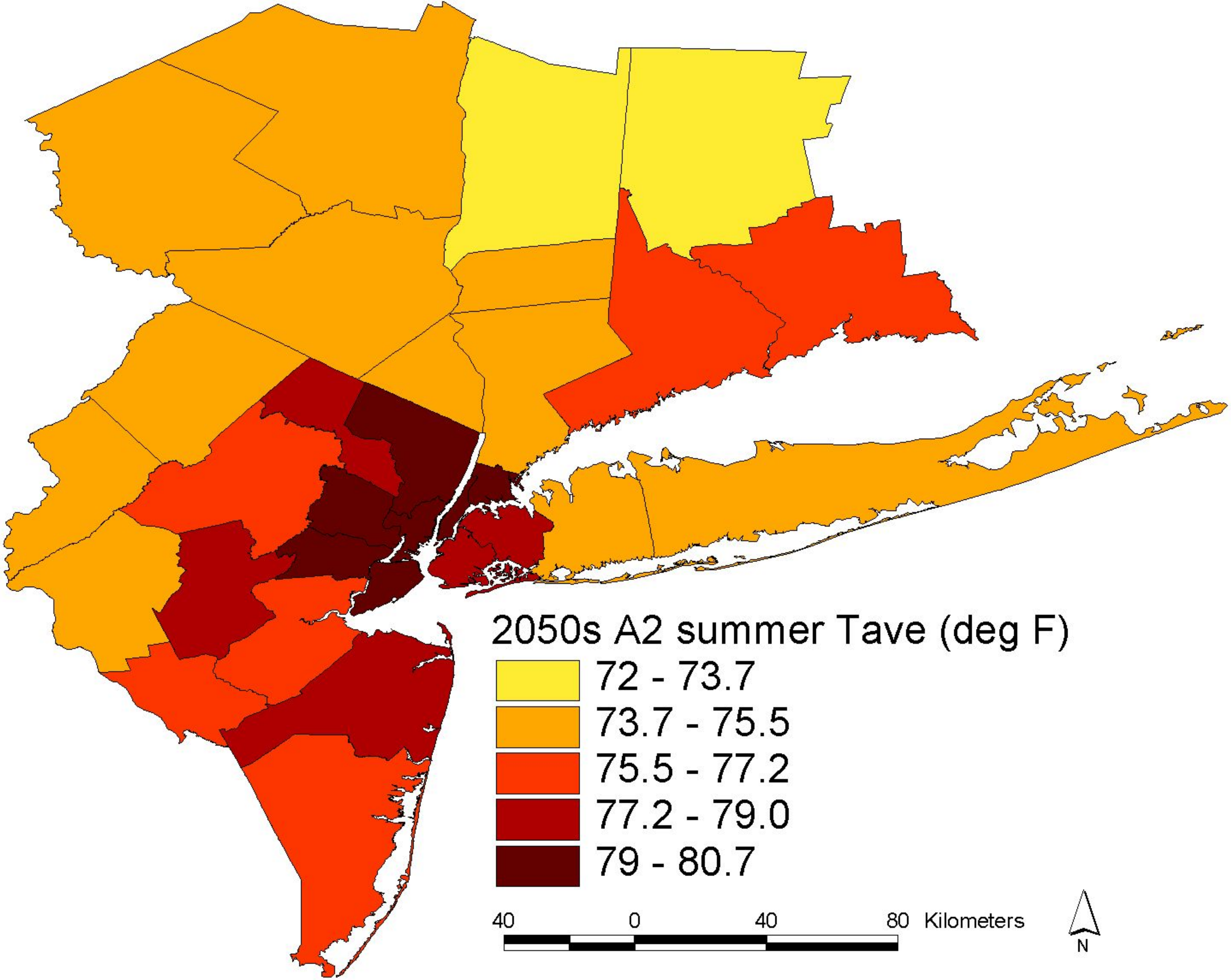


Projected Change in 2050s (A2) Summer Temperature



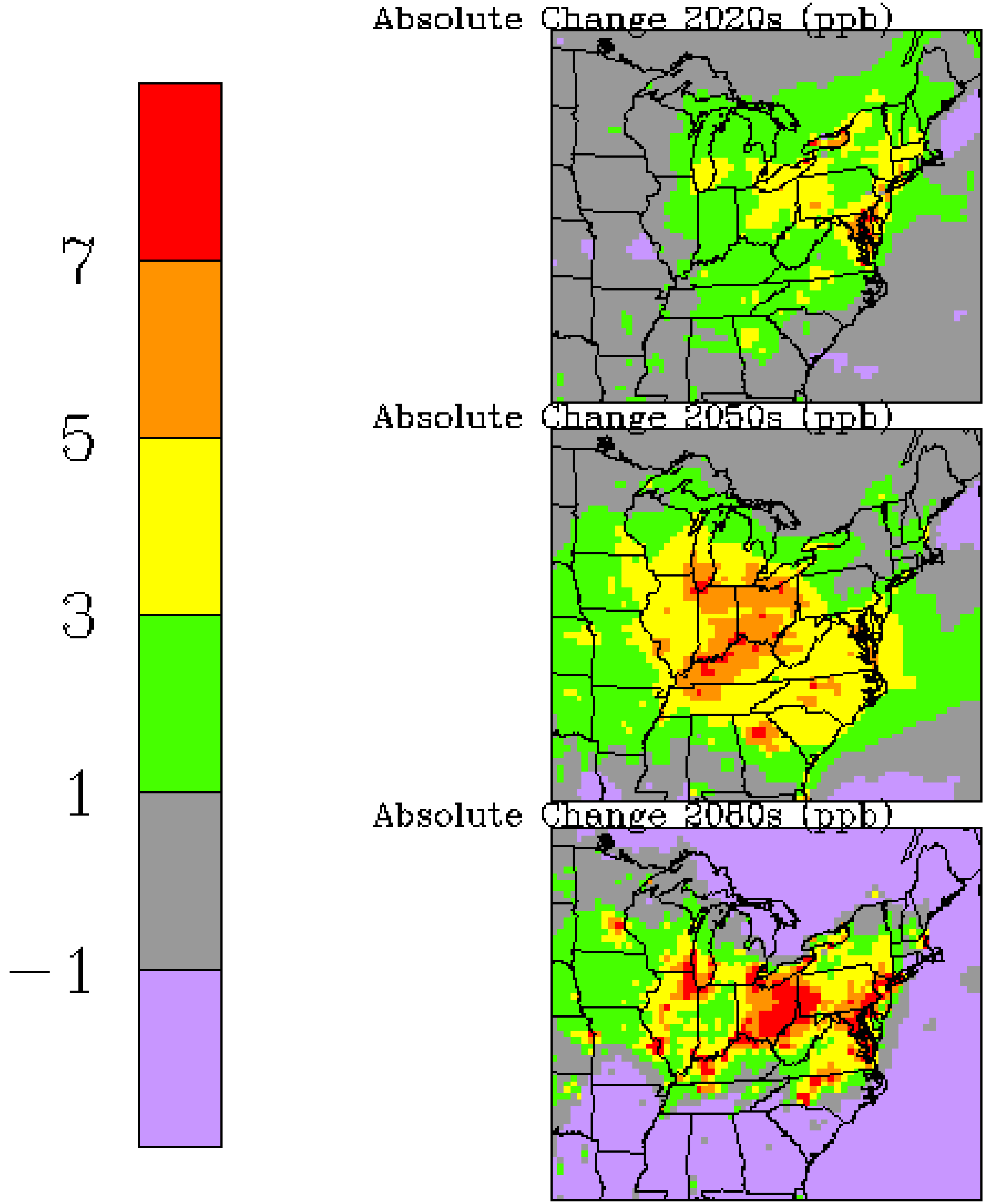
GISS: 10 years, MM5 5 years

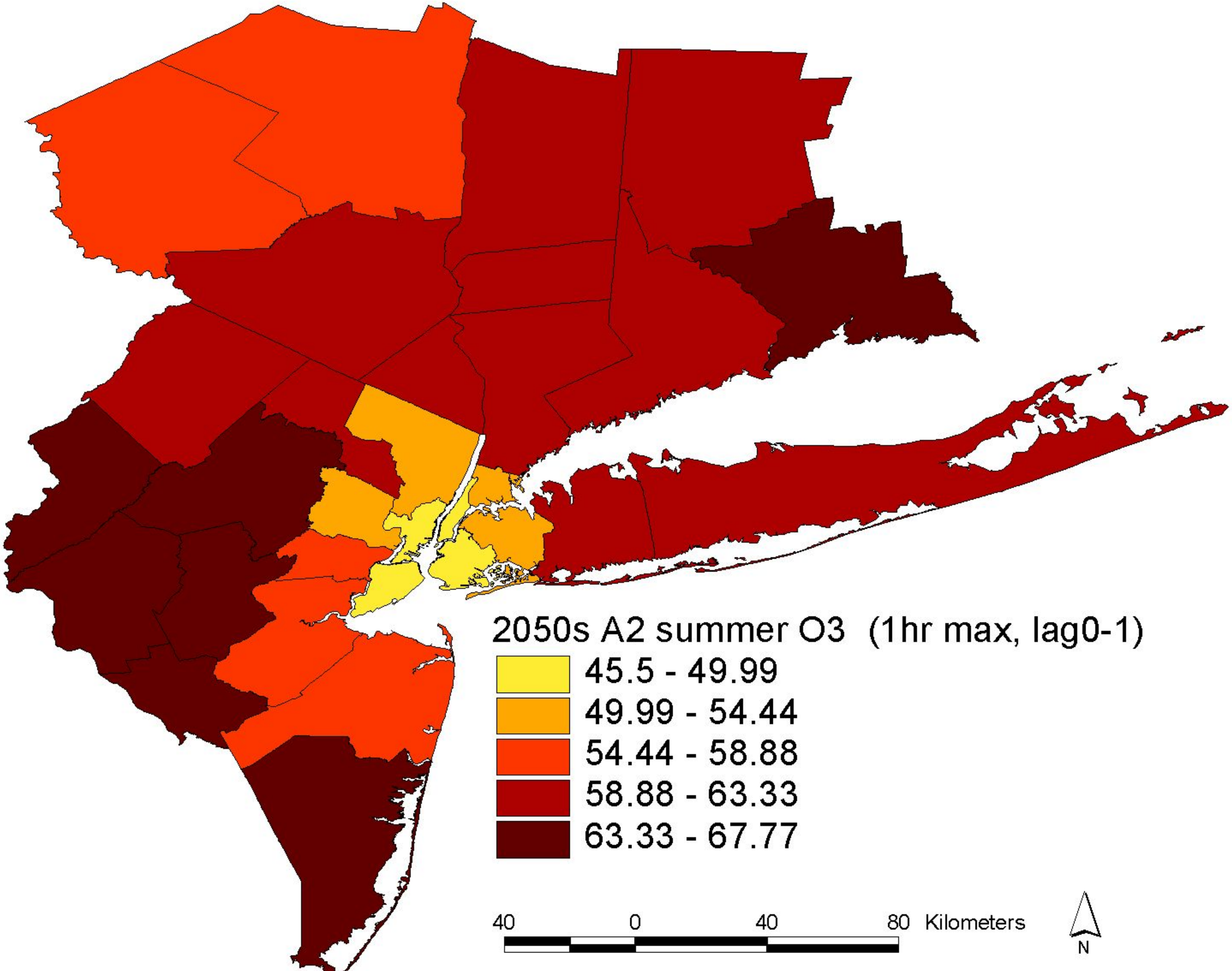
NASA/GISS Climate Impacts Group

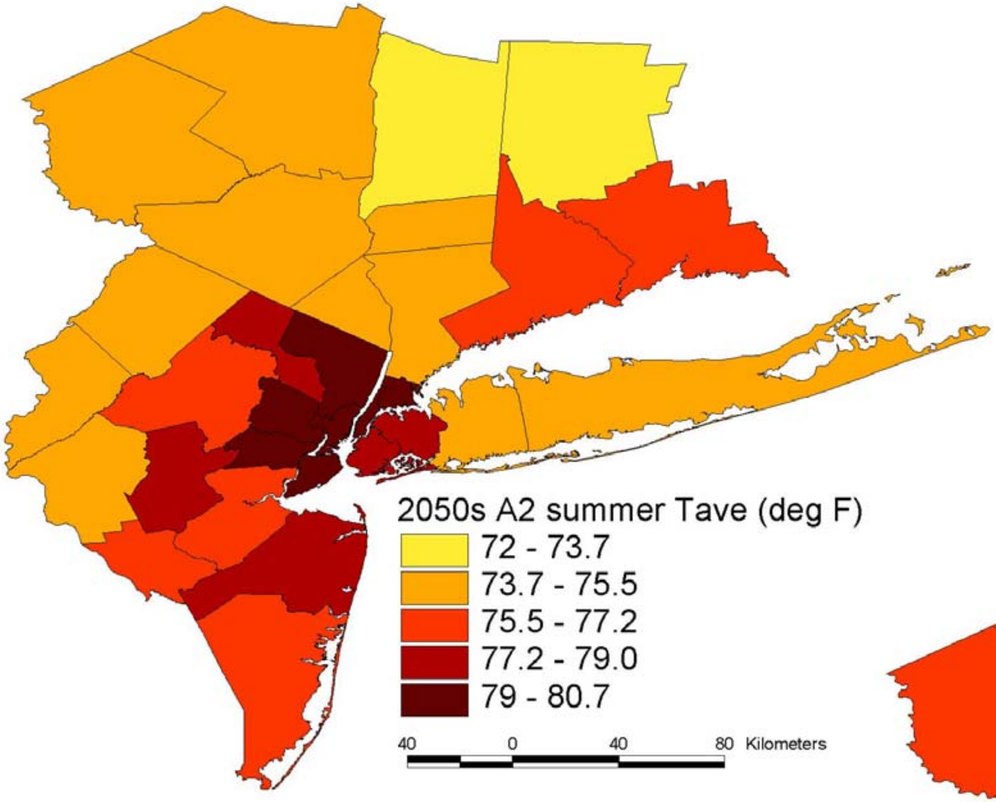

2050s A2 summer Tave (deg F)
72 - 73.7
73.7 - 75.5
75.5 - 77.2
77.2 - 79.0
79 - 80.7
40 0 40 80 Kilometers
N

A2 Change in Ozone (ppb)

2020s
2050s
2080s

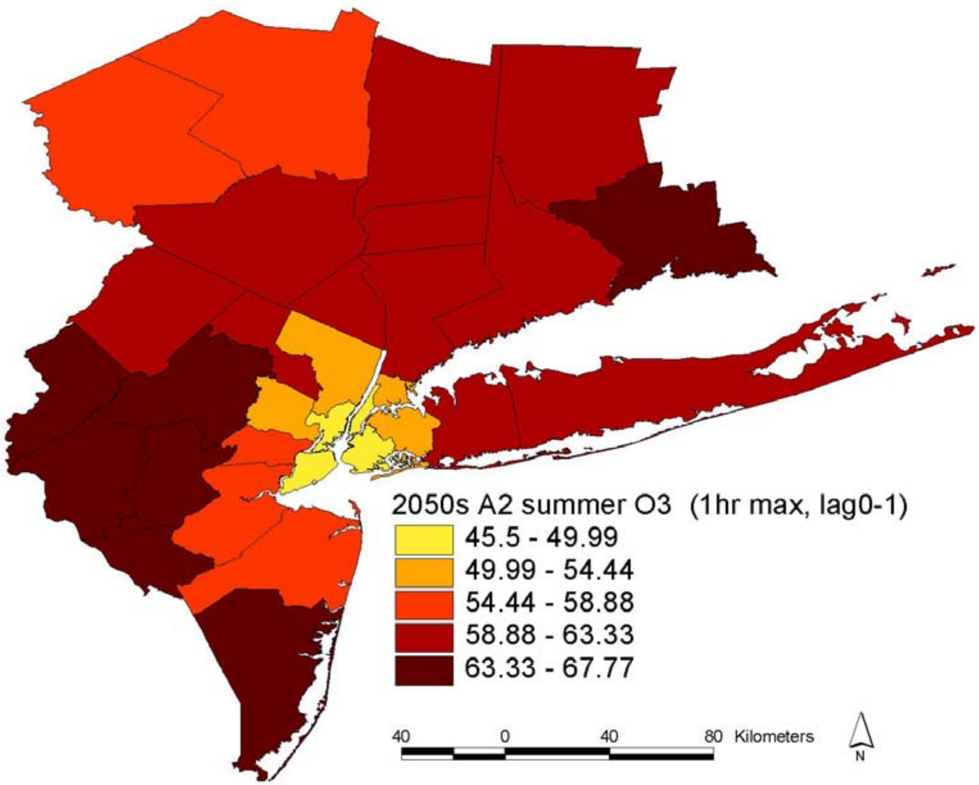



2050s A2 summer O3 (1hr max, lag0-1)
45.5 - 49.99
49.99 - 54.44
54.44 - 58.88
58.88 - 63.33
63.33 - 67.77
40
0
40
80 Kilometers
N

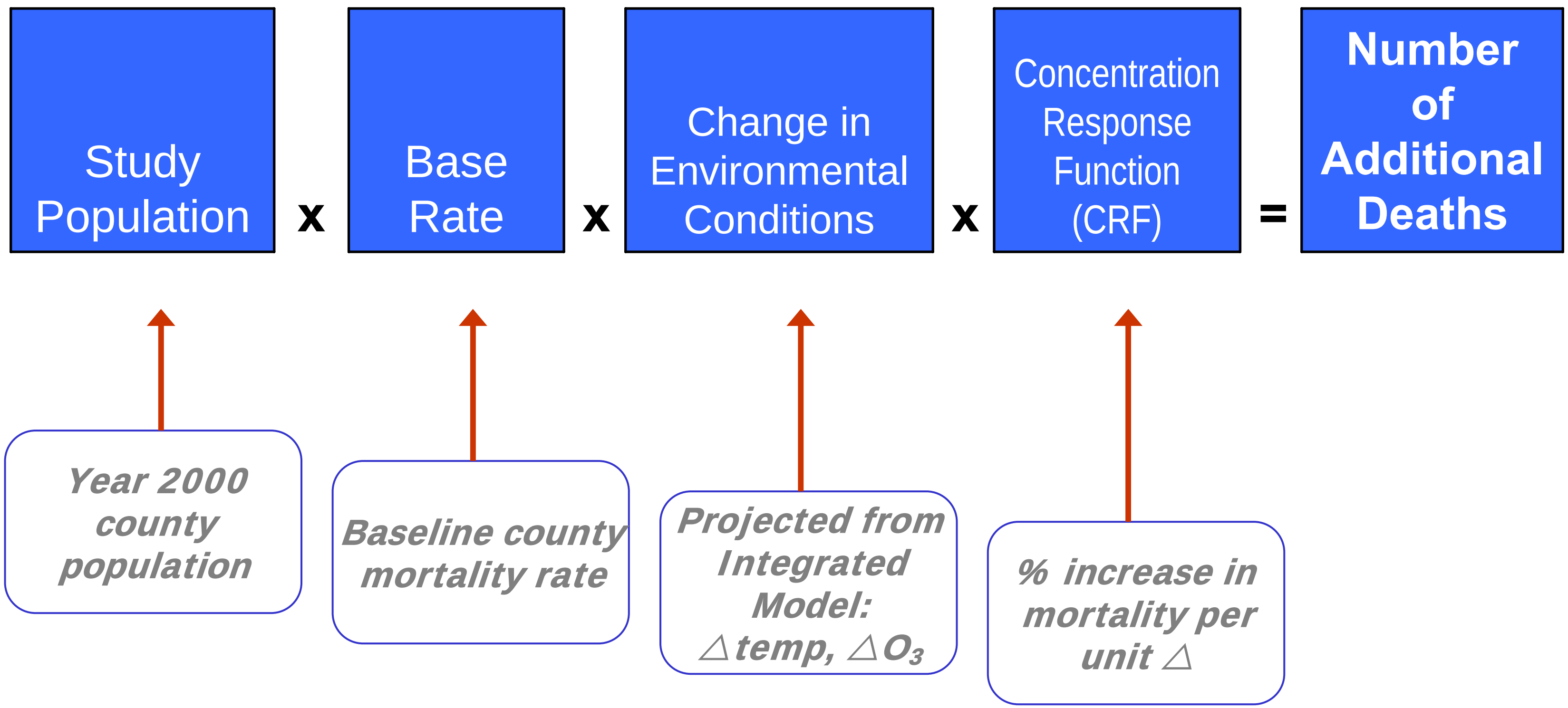


2050s Temperature

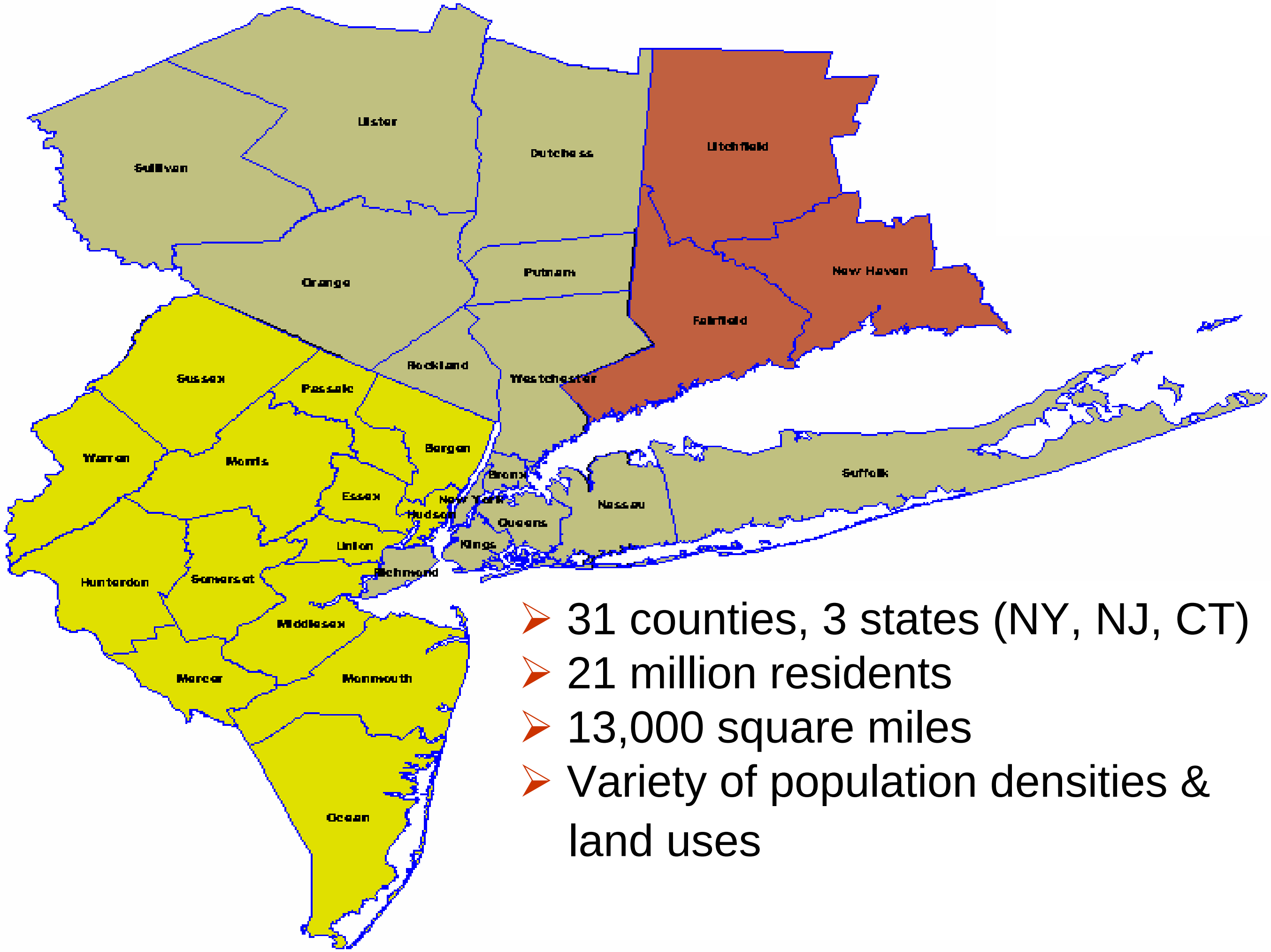
2050s Ozone



Methods 3: Risk Assessment

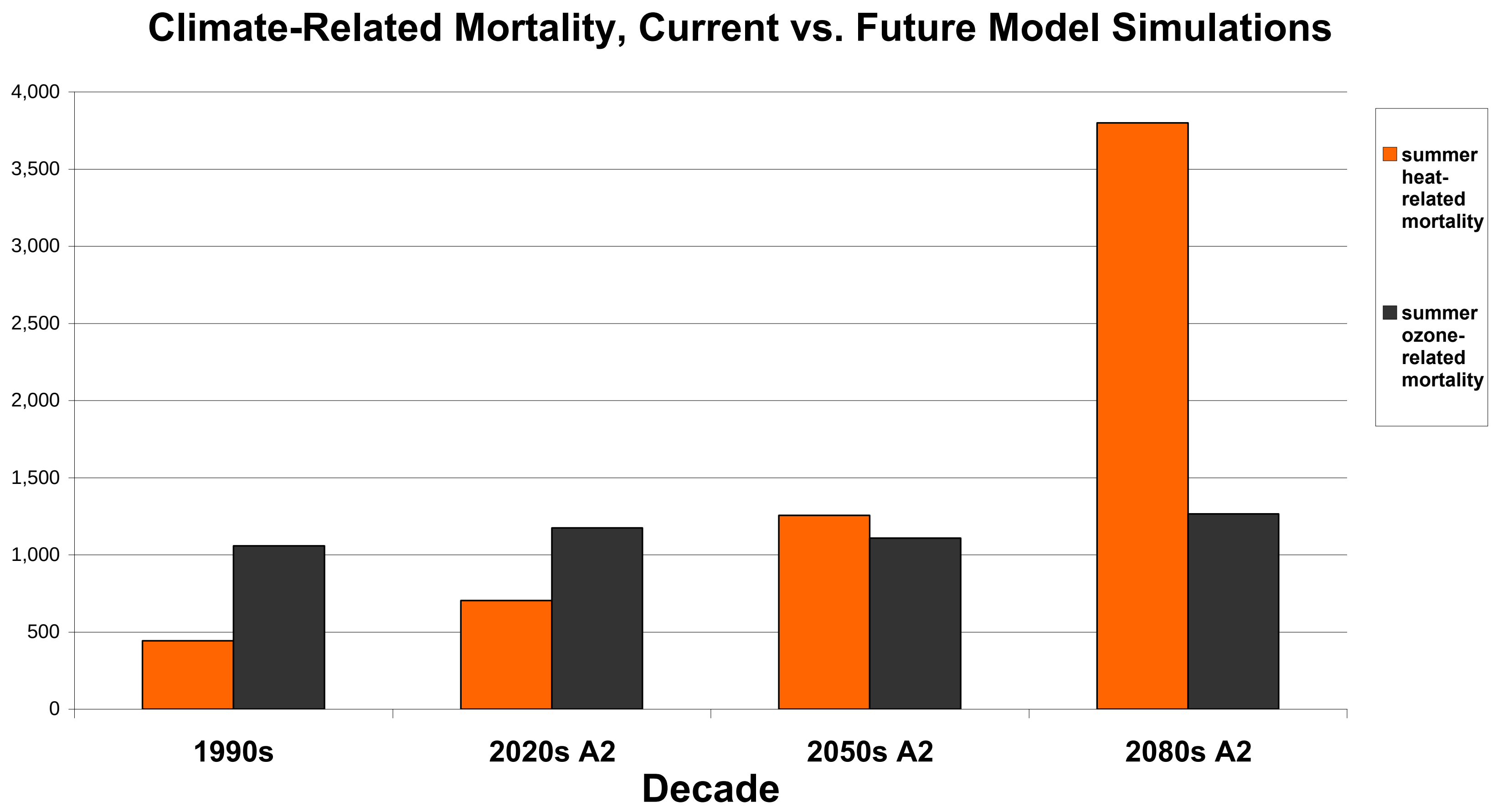


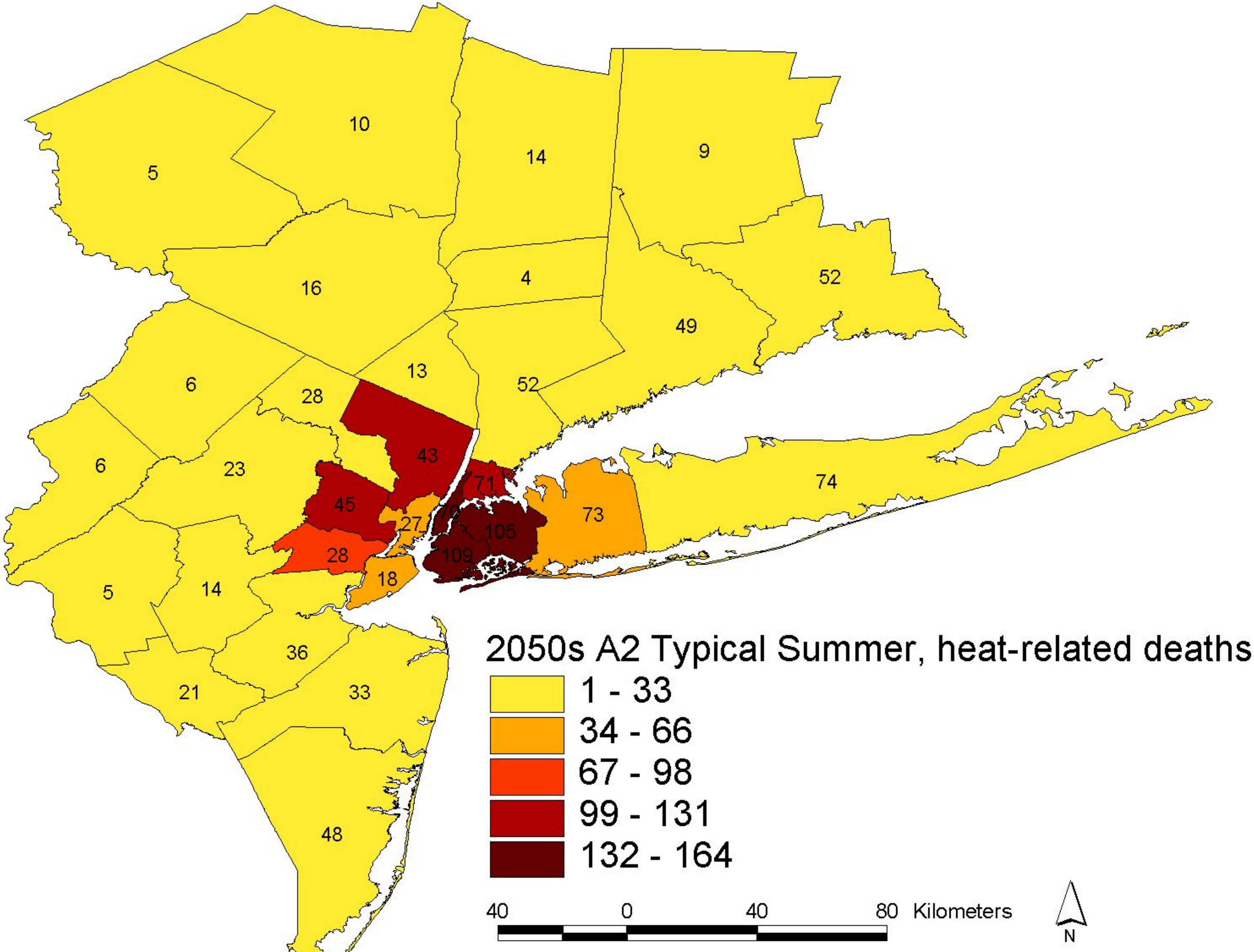
Health Impact Assessment Study Area: The New York Metropolitan Region

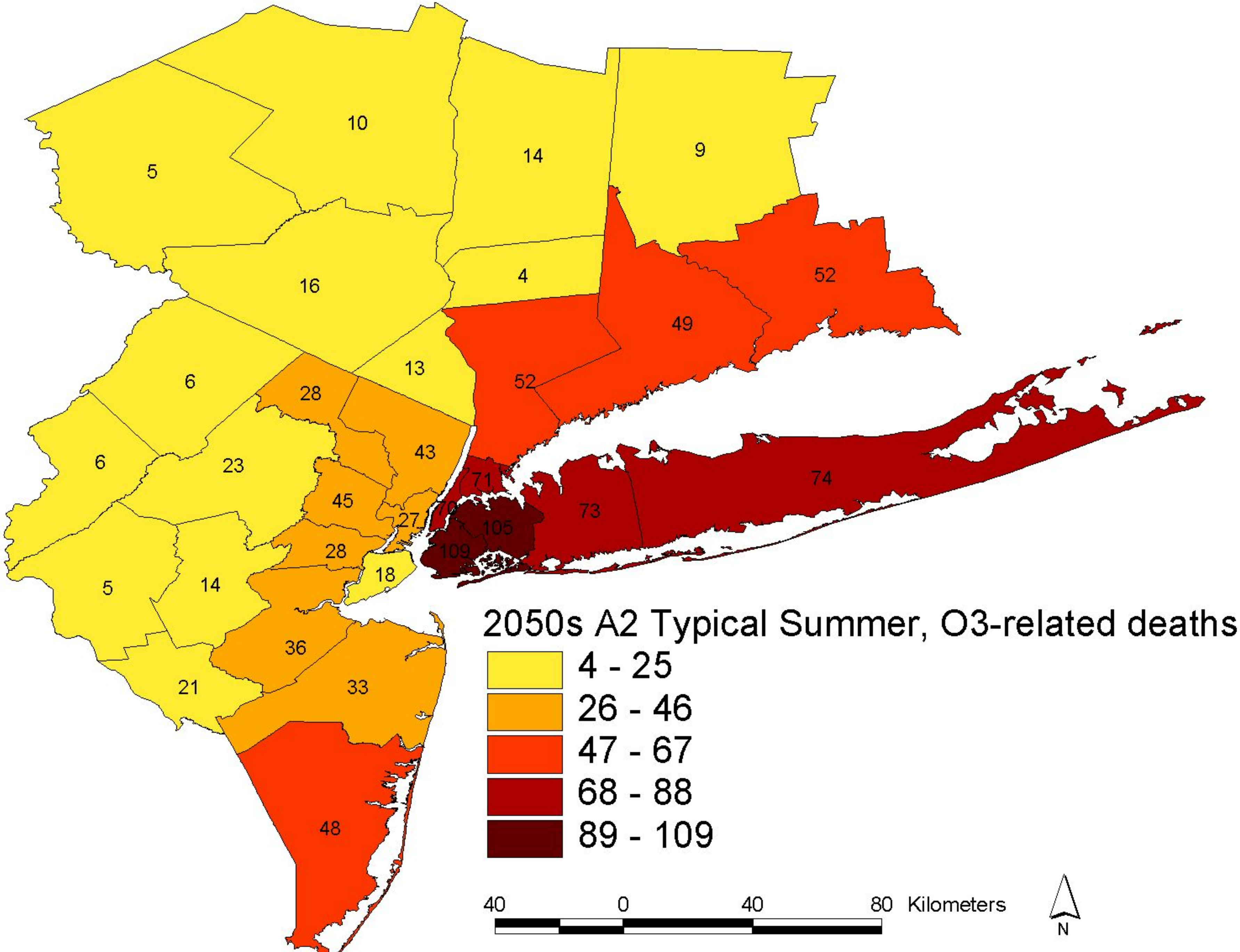


- 31 counties, 3 states (NY, NJ, CT)
- 21 million residents
- 13,000 square miles
- Variety of population densities & land uses

Results:
Comparative heat & O3 mortality risk assessment for mid-decadal summers (JJA)




10
5
14
9
16
4
52
49
13
6
28
52
43
6
23
71
74
45
27
70
105
73
28
109
18
5
14
36
21
33
48
2050s A2 Typical Summer, heat-related deaths
1 - 33
34 - 66
67 - 98
99 - 131
132 - 164
40
0
40
80
Kilometers
N


2050s A2 Typical Summer, O3-related deaths
4 - 25
26 - 46
47 - 67
68 - 88
89 - 109
40
0
40
80
Kilometers
N
10
5
14
9
16
4
52
49
6
13
52
28
6
43
23
71
74
45
73
70
27
105
28
109
5
14
18
36
33
21
48

Sensitivity analysis: Mortality Risk Assessment results using alternative IPCC SRES scenario

	1990s	**2050s B2** (lower CO_2 emissions)	**2050s A2** (higher CO_2 emissions)
Summer heat-related mortality	**443**	**1,025** ***131.4%***	**1,256** ***183.5%***
Summer O_3-related mortality	**1,059**	**1,139** ***7.6%***	**1,108** ***4.6%***

Summary

Location-specific projections of heat and ozone-related deaths associated with changing climate have been developed for the NYC metro area

Both temperature and ozone were significantly associated with daily deaths when included simultaneously in time series model

A dynamically-downscaled climate/air quality modeling system was developed to estimate 36 km temp and ozone in future decades

Geographic distribution of environmental impacts differed for temp and ozone

Relative mortality impact of temperature vs. ozone projected to increase over time

Research Needs

Include other global and regional climate models - "ensemble" concept

Develop PM2.5 estimates using integrated modeling system

Include other health outcomes in addition to mortality

Include adaptation module for heat effects

Get more people involved - training; funding; communication